Number of finishers and performance of age group women and men in long-distance running: comparison among 10km, half-marathon and marathon races in Oslo

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Abstract: The aim of the present study was to examine the number of finishers and performance trends in 10 km, half-marathon and marathon races in Oslo. Data (total 115,725 finishers; women, n = 50,595; men, n = 65,130) from 10 km, half-marathon and marathon races in Oslo from 2008 to 2018 were analysed considering number, sex, age and running speed of finishers. The total men-to-women ratio was the smallest in the 10 km race (0.60) and the largest in the marathon (3.86) ($p < 0.01$, $\varphi = 0.28$). In both women and men, the slowest running speed was shown in the older age groups ($p < 0.01$). Based on the findings of the present study, it was concluded that relatively more women finished a 10 km and less a half-marathon and a marathon. Our results indicated that the sex difference in performance was attenuated in the longer race distances and older age groups.

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NUMBER OF FINISHERS AND PERFORMANCE OF AGE GROUP WOMEN AND MEN IN LONG DISTANCE RUNNING: COMPARISON AMONG 10KM, HALF-MARATHON AND MARATHON RACES IN OSLO

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ABSTRACT

The aim of the present study was to examine the number of finishers and performance trends in 10 km, half-marathon and marathon races in Oslo. Data (total 115,725 finishers; women, n=50,595; men, n=65,130) from 10 km, half-marathon and marathon races in Oslo from 2008 to 2018 were analyzed considering number, sex, age and running speed of finishers. The total men-to-women ratio was the smallest in the 10 km race (0.60) and the largest in the marathon (3.86) (p<0.01, φ=0.28). In both women and men, the slowest running speed was shown in the older age groups (p<0.01). Based on the findings of the present study, it was concluded that relatively more women finished a 10 km and less a half-marathon and a marathon. Our results indicated that the sex difference in performance was attenuated in the longer race distances and older age groups.

Keywords: aging, endurance, gender, outdoor exercise, race speed, recreational, running

INTRODUCTION

The number of finishers in endurance and ultra-endurance events has shown an exponential increase in recent years (Belinchon-Demiguel & Clemente-Suarez, 2019). Long-distance runners have considered finishing a shorter race distance as a milestone before participating in a longer race (Deaner, Addona, Carter, Joyner, & Hunter, 2016). In addition, marathon runners might participate in shorter race distances during their preparation for a major marathon race (Salinero et al., 2017). Thus, being aware of the number of finishers and performance differences among major long-distance races such as 10 km, half-marathon and marathon it would be necessary to optimize endurance training of long-distance runners. It is commonly known that marathon or ultra-endurance runners use competitions of shorter distances in order to improve pace time as a common training strategy (Coquart, Alberty, & Bosquet, 2009).The higher intensity of shorter races as 10 km allow marathon runners to improve their maintenance of a higher percentage of maximal oxygen uptake and maximal lactate steady state during longer time, a basic fact for longer distance like half-marathon, marathon or even races of longer distances (Belinchon-de Miguel & Clemente-Suarez, 2018).

The number of finishers in marathon races increased during the last decades. For instance, ~350,000 marathon runners finished the 'New York City Marathon' in 2000-2009 and ~344,000 in 2010-2017 compared to ~25,000 in 1970-1979 (Vitti, Nikolaidis, Villiger, Onywera, & Knechtle, 2019). This increase was especially attributed to women (increase +50 times in women versus +10 times in men from 1970s to 2000s) and master runners competing in older age groups (Vitti et al., 2019). Despite the relationship among 10 km, half-marathon and marathon performances - *i.e.*, one performing well in one of them would be expected to perform well to another (Coquart et al., 2009; McKelvie, Valliant, & Asu, 1985; Salinero et al., 2017) - trends in

the number of finishers and performance might differ among them. For instance, it has been reported that more runners finished in a half-marathon than in a marathon race, whereas marathon runners were faster than their half-marathon counterparts (Knechtle, Nikolaidis, Zingg, Rosemann, & Rust, 2016).

Although previous studies in this topic improved our understanding of the number of finishers and performance trends in half-marathon and marathon, less information has been available on 10 km races with regards to longer race distances. Such information would be of great practical important for strength and conditioning coaches working with long-distance runners considering that runners competed in these race distances interchangeably. Thus, the aims of the present study were (*i*) to examine trends of the number of finishers in three popular race distances - 10 km, half-marathon and marathon races; and (*ii*) to assess performance of men and women by age group in these three long-distance races.

METHODS

Ethical approval

This study was approved by the Institutional Review Board of Kanton St. Gallen, Switzerland, with a waiver of the requirement for informed consent of the participants as the study involved the analysis of publicly available data. The study was conducted in accordance with recognized ethical standards according to the Declaration of Helsinki adopted in 1964 and revised in 2013.

Data

For the purpose of this study, we included official results from Oslo Marathon from 2008 to 2018 (https://oslomaraton.no/). Results were collected from all three races (*i.e.* 10 km race, half-marathon and marathon), held on the same day, on the officially certified and rather flat track (elevation ranging from 0 to 60 m). For comparison, Berlin Marathon, considered to be "the fastest marathon" has elevation difference of 21m (Nikolaidis, Cuk, Rosemann, & Knechtle, 2019). Participants who did not finish a race, or where no information about age or sex was available, were excluded from the initial sample (**Figure 1**). In total 115,725 finishers were included in this study (men, *n*=65,130; women, *n*=50,595).

- Insert Figure 1 here -

Procedures

Age intervals were selected to represent younger and older group of adult runners (*i.e.* 18-23 years of age and 24-34 years of age, respectively), as well as masters runners in their categories (5-years-interval). Runners older than 70 years of age were all sorted in one category, since there

were only few runners in oldest age groups. In total, finishers were classified into 10 age groups; 18-23, 24-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69 and 70+ years.

Statistical analysis

Final race time in seconds was obtained for all finishers in all three races. Subsequently, average running speed in km/h was calculated using the formula "final race time (h) / race distance (km)". This calculation allowed the comparison of performance of all three long-distance races. Prior to all statistical tests, descriptive statistics were calculated as mean and standard deviation. Moreover, data distribution normality was verified by visual inspection of histograms and QQ plots (Cuk, Nikolaidis, & Knechtle, 2019; Nikolaidis, Rosemann, & Knechtle, 2018). To assess age group and sex distribution among finishers in three long distance races (*i.e.* 10 km race, half-marathon and marathon), which is in line with the first aim of this study, we used a chi-square test (χ^2). Specifically, we examined the association between finishers' *sex* and *race*, as well as between their *sex* and *age group*, separately for each race. The magnitude of these associations was tested by Cramer's phi (φ). Results were presented as a men-to-women ratio (MWR) to evaluate the relative number of finishers by sex. To test differences in performance (*i.e.* average running speed) of men and women in age group in three long-distance races, three-way analyses of variance (ANOVA) was performed. The ANOVA was applied to test main effects of *sex* (*i.e.* men and women), *race* (*i.e.* 10 km race, half-marathon and marathon) and *age group* as well as their interactions: *sex x race; sex x age group; race x age group; sex x race x age group*. In addition, Bonferroni post-hoc test was performed. Effects size was presented using eta squared (η^2), where the values of .01, .06 and above .14 were considered small, medium, and large, respectively (Cohen, 1988). Alpha level was set at $p<0.05$. All statistical tests were performed

using Microsoft Office Excel 2007 (Microsoft Corporation, Redmond, WA, USA) and SPSS 20 (IBM, Armonk, NY, USA).

RESULTS

The men-to-women ratio

The MWR as well as the total number of men and women in their age group in all three races is presented in **Table 1.** The total MWR was 1.29. A *sex* x *race* association was shown, (χ^2=8899.2, p<0.01, φ=0.28), where the MWR was the smallest in the 10 km race (0.60) and the largest in the marathon (3.86). Furthermore, a *sex* x *age group* association was also shown in the 10 km race (χ^2=553.5, p<0.01, φ=0.13), the half-marathon (χ^2=1323.9, p<0.01, φ=0.14) and the marathon (χ^2=107.3, p<0.01, φ=0.08). In both the 10 km and the half-marathon, the smallest MWR was observed in the youngest age group (0.45 and 0.78, respectively), whereas the largest MWR was observed in the oldest age group (3.20 and 5.91, respectively). In the marathon, the smallest MWR was observed in the 24-34 age group, whereas the largest MWR was observed in the 65-69 age group.

Performance of age group men and women in long distance running events

When performance of age group men and women in long-distance running events was observed, the three-way ANOVA showed significant main effects for *sex* [$F_{(1,115665)}$=1648.4, η^2=0.06, p<0.01], *race* [$F_{(2,115665)}$=78.9, η^2=0.01, p<0.01] as well as *age group* [$F_{(9,115665)}$=180.2, η^2=0.06, p<0.01]. Moreover, the three-way ANOVA showed significant interactions for *sex x race* [$F_{(2,115665)}$=36.2, η^2<0.01, p<0.01] and *race x age group* [$F_{(18,115665)}$=16.8, η^2=0.01, p<0.01], whereas no interaction was observed in *sex x age group* [$F_{(9,115665)}$=1.4, η^2<0.01, p=0.164]. Finally, interactions between *sex x race x age group* were statistically significant [$F_{(18,115665)}$=2.8, η^2<0.01, p<0.01]. Additional post-hoc tests were performed to assess performance of men and women in

long-distance events (**Figure 2**). Finally, the same post-hoc tests were performed to assess performance of age group in long-distance running events **(Figure 3)**.

- Insert Figure 2 here **-**

- Insert Figure 3 here**-**

Performance of age group in long distance running events

The fastest men competed in the half-marathon race (11.60 km/h) and the slowest in the marathon race (11.07 km/h). In general, the fastest men were the youngest (11.65 km/h), whereas the oldest men were the slowest (9.51 km/h). Regarding the *race x age group* interaction, the greatest differences between races were observed in the youngest age group (*i.e.* 18-23 years of age). Runners in the 10 km race were 1.43 km/h faster than the marathon runners of the same age.

Half-marathon runners were the fastest women (10.22 km/h), and 10 km runners the slowest (9.75 km/h). Similar to men, the fastest women were also the youngest one (10.28 km/h), whereas the oldest women were the slowest (8.24 km/h). Regarding the *race x age group* interaction, the greatest differences between races were observed between the 10 km race and the marathon in age group 65-69 years (1.00 km/h in favor of marathon runners).

Performance of men and women in age group

Men were faster than women in the 10 km race (11.43 km/h in comparison to 9.75 km/h). In addition, the youngest age group was the fastest one (10.88 km/h), whereas the oldest age group was the slowest one (8.90 km/h). Regarding the *sex x age group* interaction, the greatest

differences between men and women in the 10 km race were observed in the youngest age group (2.01 km/h in favor of men).

Similar to the 10 km race, half-marathon men were faster than women (11.60 km/h in comparison to 10.22 km/h). In addition, the two youngest age groups (*i.e.* 18-23 and 24-34) were the fastest ones (11.09 km/h), whereas oldest age group was the slowest one (9.67 km/h). Contrary to the 10 km race, the greatest differences between men and women in half-marathon were observed in oldest age group (1.68 km/h in favor of men).

Regarding marathon, men were faster than women (11.07 km/h in comparison to 10.14 km/h). Contrary to the 10 km race and the half-marathon, the fastest marathon runners were in age group 35-39 years (11.12 km/h), whereas the slowest marathoners were in the oldest age group (9.07 km/h). Regarding the *sex x age group* interaction, the greatest differences between men and women were observed in the age group 60-64 years (1.35 km/h in favor of men).

DISCUSSION

The first aim of this study was to assess age group and sex distribution among finishers in three long-distance races (*i.e.* 10 km race, half-marathon and marathon), whereas the second aim was to assess the performance of men and women in age group in the same races. Regarding the first aim, the main findings were that (*i*) more women than men finished in the 10 km race, while more men finished in the half-marathon and the marathon; (*ii*) more women finished in the younger age in all races. Regarding the second aim, the main findings were that (*i*) men were faster than women in all races; (*ii*) both men and women half-marathon runners were faster than 10 km and marathon runners; (*iii*) men were faster than women in all age groups, with the exception of marathoners older than 65 years of age; (*iv*) in both the 10 km race and the half-marathon, the youngest runners were the fastest, whereas the oldest runners were the slowest; and (*v*) in the marathon, the fastest men and women runners were in age group 35-39 years, whereas the oldest runners were the slowest.

The number of finishers by race distance and men-to-women ratio

In terms of the number of finishers by race distance, half-marathon runners were ~2 times the number of 10 km runners and the marathon race had the smallest number of finishers, which was in agreement with previous findings. In Switzerland, half-marathon runners were 2.6 times the number of marathon runners during 2000-2010 (Anthony et al., 2014). In addition, half-marathon runners were 1.4 times the number of 10 km runners in the Singapore Army Half-marathon during 2010-2012 (Tan, Tan, Kok, Lee, & Lee, 2014).

An interpretation of the variation of the number of finishers by race distance might be differences in physiological demands among race distances. Half-marathon seemed the most

popular and marathon was the most physiological demanding, whereas 10 km might be considered as a 'first step' towards longer race distances. Furthermore, it was indicated that endurance runners could 'shift' easier from 10 km to half-marathon than from half-marathon to marathon. Physiological demands of marathon running related with the increased muscle damage, hyperthermia and dehydration preclude a higher number of finishers in this long-distance race (Del Coso et al., 2013). In this line, the metabolic demands, that produce a depletion of glycogen stores leading in runners to the famous "hitting the wall" and producing an increased avoidance behavior which also precludes half-marathon runner to step into the distance of marathon (Buman, Omli, Giacobbi, & Brewer, 2008). This fact is also more prevalent among men than among women and may be influenced by expectancy, a fact that could also influence the gender differences in the number of finishers (Buman, Brewer, Cornelius, Van Raalte, & Petitpas, 2008).

The higher number of finishers of women in the 10 km race than men (MWR 0.60) was a novel finding, whereas the lower number of finishers of women in both the half-marathon (MWR 1.45) and the marathon than men (MWR 3.86) was in agreement with the existing literature. For instance, the MWR was 2.50 in half-marathon and 4.74 in marathons held in Switzerland (Anthony et al., 2014). Despite this variation of the MWR by country (*i.e.* Norway *vs.* Switzerland), a common trend of a larger number of finishers of men in the longer race distances should be highlighted. This trend of a higher number of finishers of men than women was also observed in a longer distance event like the 'Marathon des Sables' (7 day competition) with a MWR of 6.76 (Knoth, Knechtle, Rust, Rosemann, & Lepers, 2012), the 'Western States 100-Mile Endurance Run' (161 km) with a MWR of 5.28 (Hoffman & Wegelin, 2009), or Double Iron ultra-triathlon (MWR: 8.96) to Deca Iron ultra-triathlon (MWR: 6.94) (Knechtle, Knechtle,

& Lepers, 2011), but as well as in 10 km, half-marathon and marathon an increased tendency of women finishers was observed, then in the next years the MWR would tend to decrease in all endurance and ultra-endurance events. An explanation of the variation of MWR by race distance might be the consideration of women as relatively 'novice' runners compared to men, *e.g.* MWR decreased from 10.2 in 1970's to 1.5 in 2010's in the 'New York City Marathon' (Vitti et al., 2019). Considering women as 'novice' runners and the trend that novice runners would participate first in short distance races before attempting to finish a longer distance race, the relatively higher number of women finishers in the 10 km than in the longer distances was not surprising.

With regards to the variation of the number of finishers by sex and age group, a similar trend was shown in all race distances where the MWR was higher in the older than in the younger age groups. This observation was in agreement with findings on the 'GöteborgsVarvet', the world largest half-marathon (Knechtle & Nikolaidis, 2018), and on the 'New York City Marathon' (Nikolaidis et al., 2018). Consequently, considering this global trend of the MWR in long-distance running, it might be assumed that the number of finishers by sex in the near future would be more balanced, especially taking into account the number of finishers of other famous marathons such as the 'New York City Marathon' in which the MWR has gone from 5.60 in 1983 to 2.47 in 1999 (Jokl, Sethi, & Cooper, 2004).

Performance by sex, age and race distance

The sex difference (faster performance in men than women) decreased by race distance, *i.e.* it was 17.0% in the 10 km, 13.4% in the half-marathon and 8.9% in the marathon. This variation might be attributed to trends of the number of finishers by sex and race distance, since the

number of women was higher with decreasing race distance and women were slower than men. The faster race speed in men than women might be interpreted by sex differences in human physiology and training habits. With regards to physiology, men half-marathon runners were heavier with lower body fat than women (Knechtle, Knechtle, Rosemann, & Senn, 2010). Furthermore, men middle distance and marathon runners had higher maximal oxygen uptake (VO_2max) and anaerobic threshold than women (Maldonado-Martín, Mujika, & Padilla, 2004). With regards to training habits, it has been reported that competitive men marathon runners had more sport experience, weekly training units and distance than women (Karp, 2007), whereas in half-marathon, men had faster training running speed than women (Knechtle et al., 2010). The greater sex difference in velocity that occurs with age could be also explained by the lower number of women finishers than men (Hunter & Stevens, 2013). By contrary, the increased performance of women in the group of marathoners older than 65 years of age was a new finding, showing how the physiological differences that explain differences in younger ages are decreased in advanced ages. In addition, this finding might be explained in terms of the small number of elder women finishers, which indicated that this age group was 'selective' consisted by relatively well-trained runners (Hunter & Stevens, 2013).

In all race distances, the slowest running speed was observed in the older age groups, which was in agreement with previous research in half-marathon (Knechtle & Nikolaidis, 2018) and marathon (Nikolaidis et al., 2018) running. An interpretation of the slower running speed in the older age groups might be explained by the decline of the aerobic capacity with aging. Declining cardiovascular and muscular function, changes in biomechanics and greater susceptibility to running-related injury have been reported as factors of the decline of aerobic capacity (Willy & Paquette, 2019). With regards to the physiological determinants of performance in long-distance

races, VO_2max was the parameter most altered by age, whereas exercise economy and lactate threshold would decline to a lesser extent (Lepers & Stapley, 2016).

Limitations, strength and practical applications

A limitation of the present study was that it referred to a specific race ('Oslo Marathon'); thus, especially the novel findings on the number of finishers and performance in 10 km race should be generalized with caution to other races of this distance in different competitive and geographical settings. Also, the relatively small sample size of the two oldest age groups of women marathon runners should be noted. Strength of the study was its novelty as it was the first one to report the number of finishers and the performance trends in a 10 km race compared to half-marathon and marathon races.Considering the actual increased number of long-distance runners and races worldwide, new demands for scientific research have been posed in order to provide practical applications to strength and conditioning coaches working with recreational long distance runners. Runners might participate interchangeably in races differing for distance, *e.g.* competing in a 10 km race as a 'first step' towards longer distances in the future or in a half-marathon during the preparation period before a marathon race. In addition, in view of the increased number women and athletes in older age groups in long-distance running, strength and conditioning coaches might be requested to prescribe exercise for recreational runners with a wide variation of characteristics in terms of sex, age and race distance. In this context, strength and conditioning coaches should be aware of the variation of the number of finishers and performance by sex, age and race distance.

CONCLUSIONS

Based on the findings of the present study, it was concluded more women finished in a 10 km and less in a half-marathon and a marathon than men, and an increased number of women finishers was observed in the younger age groups for all race distances. Our results confirmed the better performance of men in long-distance running than women and indicated that the sex difference in performance was attenuated in the longer race distances and older age groups. It should be highlighted that the analysis of performance trends was related to the variation of the MWR by age group and race distance.

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373 **Table 1**. Number of finishers by sex, age group and race distance.

Age groups	10 km race				Half-marathon				Marathon			
	Men	Women	Total	MWR	Men	Women	Total	MWR	Men	Women	Total	MWR
18-23	572	1,279	1,851	0.45	1,630	2,093	3,723	0.78	985	255	1,240	3.86
24-34	3,814	6,890	10,704	0.55	12,357	10,048	22,405	1.23	4,758	1,418	6,176	3.36
35-39	1,847	3,531	5,378	0.52	6,463	4,492	10,955	1.44	2,302	545	2,847	4.22
40-44	1,769	3,223	4,992	0.55	6,001	4,051	10,052	1.48	2,215	653	2,868	3.39
45-49	1,598	2,590	4,188	0.62	4,723	2,785	7,508	1.70	1,784	473	2,257	3.77
50-54	1,133	1,658	2,791	0.68	3,318	1,691	5,009	1.96	1,201	237	1,438	5.07
55-59	755	830	1,585	0.91	1,976	694	2,670	2.85	676	111	787	6.09
60-64	434	338	772	1.28	970	267	1,237	3.63	399	64	463	6.23
65-69	266	157	423	1.69	479	95	574	5.04	169	12	181	14.08
70+	189	59	248	3.20	260	44	304	5.91	87	12	99	7.25
Total	12,377	20,555	32,932	0.60	38,177	26,260	64,437	1.45	14,576	3,780	18,356	3.86

374 MWR=men-to-women ratio

LEGENDS OF FIGURES

Figure 1 CONSORT 2010 flow diagram.

Figure 2 Performance by sex and race distance.

** difference from women at $p < 0.01$; * difference from women at $p < 0.05$; ++ difference from 10km race at $p < 0.01$; + difference from 10km race at $p < 0.05$; ## difference from half-marathon at $p < 0.01$; # difference from half-marathon at $p < 0.05$; ^^ difference from marathon at $p < 0.01$; ^ difference from marathon at $p < 0.05$

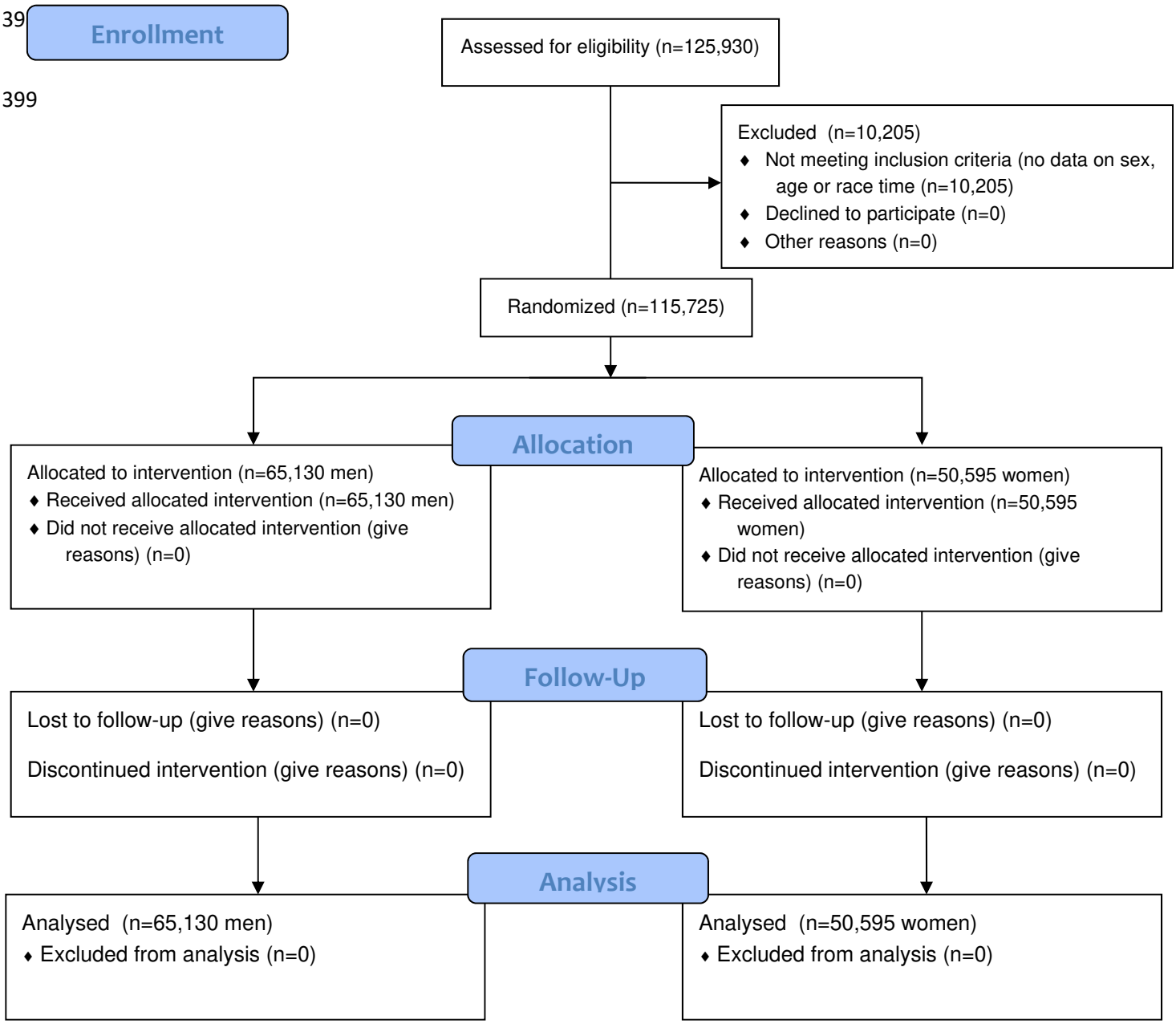
Figure 3 Performance by age group and race distance.

** difference from women at $p < 0.01$; * difference from women at $p < 0.05$; ++ difference from 10km race at $p < 0.01$; + difference from 10km race at $p < 0.05$; ## difference from half-marathon at $p < 0.01$; # difference from half-marathon at $p < 0.05$; ^^ difference from marathon at $p < 0.01$; ^ difference from marathon at $p < 0.05$

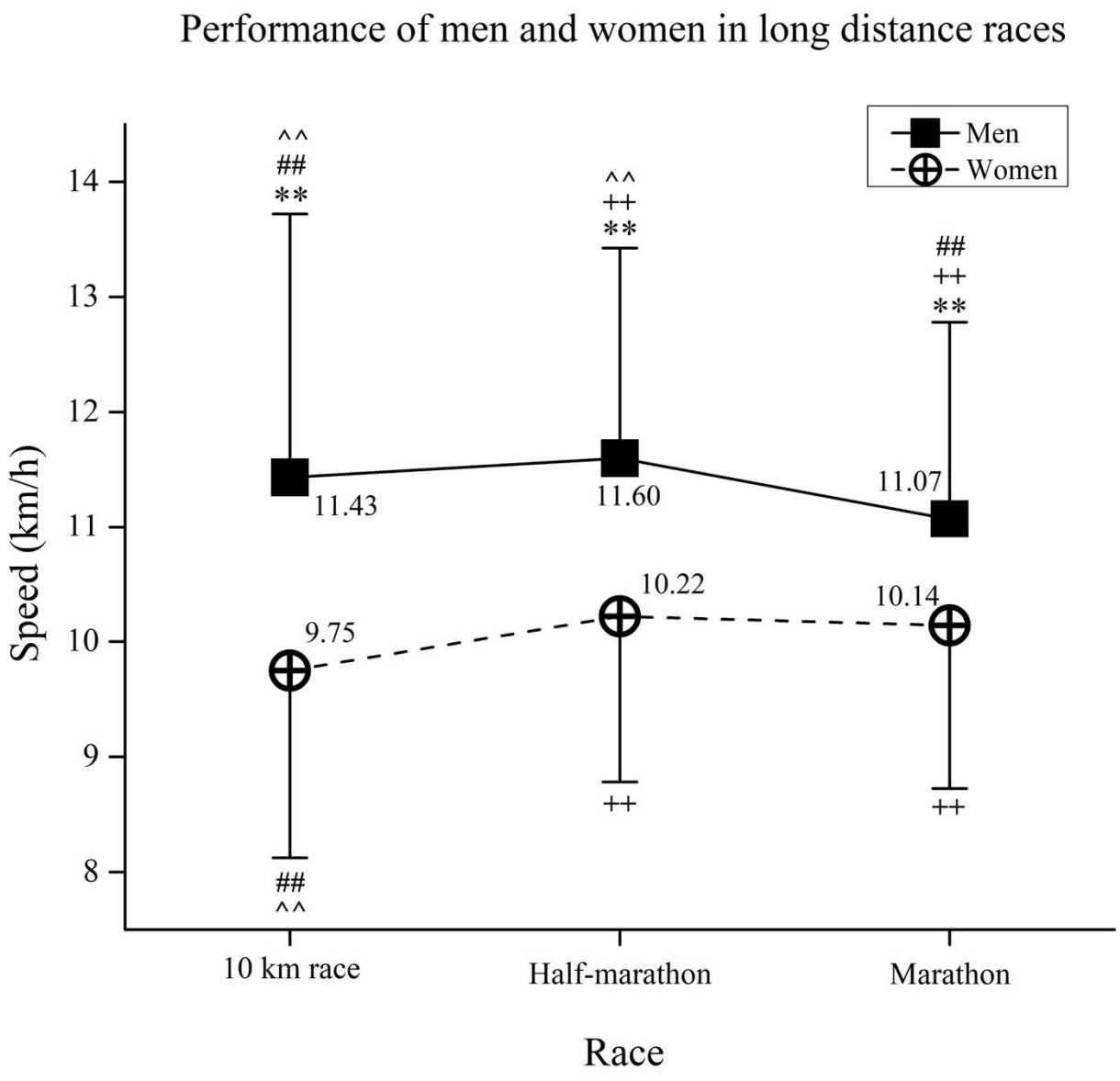
Figure 1

CONSORT
TRANSPARENT REPORTING of TRIALS

CONSORT 2010 Flow Diagram

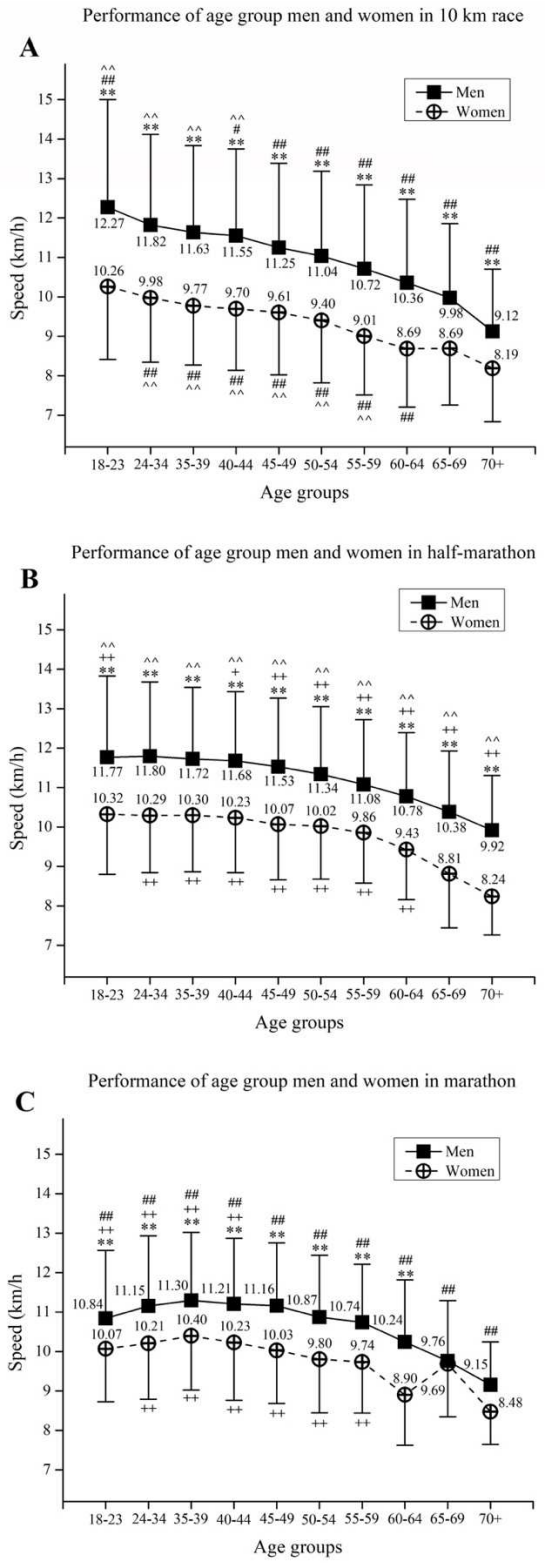


400 **Figure 2**



401

402 **Figure 3**



403